I. C. 6882 APRIL 1936

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

ALUMS AND ALUMINUM SULPHATE

BY

JOHN B. UMHAU

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By John B. Umhau[2/]

CONTENTS

	Page
Introduction	1
Description	2
Uses and substitutes	5
Aluminum sulphate minerals	6
List of minerals	9
Other aluminous raw materials	9
History	12
Methods of production from bauxite	14
Methods of production from clay	15
Byproduct sources	16
Domestic production	16
Imports	19
Tariff history	22
Exports	22
Domestic consumption	23
Markets and prices	25
List of producers	30
Bibliography	31

INTRODUCTION

Alum is primarily a product of the chemical industry obtained by treating aluminous minerals such as bauxite, clay, alunite, and leucite. However, it may be obtained directly from natural deposits, and from time to time the Bureau of Mines is called upon for advice regarding the possible marketing or exploitation of native alum, kalinite, and other aluminum sulphate minerals. The present circular attempts to bring together available information with special regard to the commercial aspects. The Bureau will welcome comments, criticism, and any additional data that might make this circular more helpful to a prospective producer.

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2/ Metals and Nonmetals Division.

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DESCRIPTION

Potash alum was the first complex alum to be recognized and the first to be manufactured commercially. The courts of Pennsylvania have held that the unmodified term, alum, in the singular means potash alum. The alums, however, comprise a series of double sulphates (or selenates) isomorphous with common alum, in which the potassium may be replaced by sodium, ammonium, rubidium, caesium, silver, or thallium, and the aluminum by iron, chromium, or other trivalent metal. Various combinations are possible and even organic base alums have been prepared. Ammonium aluminum sulphate or ammonia alum most closely resembles potassium alum. All the alums are soluble in water, all give an acid reaction when in solution, and all lose their water of crystallization when heated. The taste is characteristic - first slightly sweetish, then distinctly sour with a strong astringent action. Most of them are insoluble in alcohol.

True alum is being replaced by aluminum sulphate, which is a cheaper source of alumina, the effective agent in most uses.

Aluminum sulphate, municipal water works alum, $Al_2(SO_4)_3$ (16 to 22 percent alumina), forms (white) monoclinic crystals, which contain 18 molecules of water; it is called also concentrated alum (if alumina over 21 percent), paper makers' alum, block alum, pearl alum and pickel alum, alferite, or often merely "alum"; the commercial crystalline mass varies from white to dark brown, depending on its iron content and other impurities; the specific gravity is 2.71; and it decomposes at 770°C.

Aluminum sulphate enters commerce in two grades, both containing about 45 percent water of crystallization and approximately 37 percent SO_3: (1) Iron free, which contains less than one tenth of 1 percent of iron oxide, and (2) commercial, which contains more than one tenth of iron oxide. A small quantity is sold dehydrated.

Typical analyses of the two grades of aluminum sulphate marketed follow:

	Commercial, %	Iron free, %
Al_2O_3 total	17.5	17.5
Al_2O_3 combined	16.3	16.4
Al_2O_3 basic	1.2	1.1
Fe_2O_3	.02	.007
FeO as Fe_2O_3	.58	- -
Insoluble	.15	.10

Hoover[3/] gives the following specification for aluminum sulphate: "The material shall be basic and shall contain water-soluble aluminum sulphate

3/ Hoover, Charles P., Water Supply and Treatment: Bull. 211, National Lime Association, 1934, p. 141.

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equivalent to not less than 17 percent alumina (Al_2O_3). Percentage of insoluble material shall be stated by bidder."

Slab alum or aluminous cake, containing about 15.2 percent Al_2O_3 and about 0.2 percent to 0.75 percent ferric oxide together with insoluble earthy matter up to 10 percent, and differing in water content, is another product. Slab alum is a rectangular cake 6 by 6 by 18 inches and weighs 40 pounds. Different sizes are specified: Ingot, a lump material 1 to 2 inches in size; nut, 1/2 to 1-1/2 inches; ground, minus 8-mesh. Other sizes include pea and rice.

Alum is marketed in paper-lined barrels containing 376 pounds net, in bags (182 pounds net for a single bag and 200 pounds net for double bags), and in bulk as slabs. It is also sold in kegs, boxes, and cartons. It can be purchased in car lots (minimum 40,000 pounds) or by the barrel or bag. If kept on the basic side in manufacturing, alum does not deteriorate in storage if kept dry. If it gets wet, bags and barrels rot and the alum discolors.

Aluminum-ammonium sulphate (ammonia alum, burnt alum), $Al_2(SO_4)_3(NH_4)_2SO_4.24H_2O$, forms colorless crystals, which are insoluble in alcohol. The specific gravity is 1.645. The commercial article is sometimes a mixture of potash and ammonia alums. Grades: U.S.P., C.P., technical; lump, 375-lb. bbl.; ground, 350-lb. bbl.; powdered, 275-, 300-, 350- and 400-lb. bbl.; 200-lb. bags; 100- and 112-lb. kegs; and boxes.

A typical range of analysis of the commercial material follows:[4/]

	Maximum, percent	Minimum, percent
$Al_2(SO_4)_3$	37.67	37.17
Al_2O_3	11.25	11.1
SO_3	26.42	26.07
$(NH_4)_2SO_4$	14.50	14.30
H_2O of crystallization	0.04	0.02
Free H_2O	0.56	0.10

Aluminum-potassium sulphate is the potash alum, $Al_2(SO_4)_3K_2SO_4.24H_2O$, also known as alumen U.S.P., burnt alum, alum flowers, alum meal, cube alum. It forms white crystals and the specific gravity is 1.7571. Grades: U.S.P., C.P., technical; lump, 400-lb. bbl.; powdered, 300-lb. bbl.; 200-lb. bags; 100-lb. kegs; bulk, ground, 350 lb.; boxes, cartons.

Sodium-aluminum sulphate (soda alum, porous alum), $Al_2(SO_4)_3.Na_2SO_4.24H_2O$, forms a colorless crystal that effloresces readily in air. The specific gravity is 1.675. It is purified by recrystallization.

4/ Journal of the American Water Works Association, vol. 26, no. 9, September 1934, p. 1227.

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Effloresced sodium alum is sometimes called "porous alum", but in the trade this name is given to porous alum cake. The latter product contains a little sodium alum and basic aluminum sulphate and is made by stirring soda ash into alum cake just before it sets; due to its acidic character, the aluminum sulphate reacts with the sodium carbonate, forming carbon dioxide, which puffs the mass so that it may be dissolved readily. Grades: C.P., technical. Containers: 500-lb. casks, 400- to 500-lb. bbl., 100-lb. kegs, 25-lb. boxes.

Specifications.- In some instances, alum is purchased without specifications and in others the specifications vary considerably. The American Engineering Standards Committee, 29 West 39th Street, New York, N.Y., acts as a central distributing agent for the specifications below marked with an asterisk. Copies of specifications adopted by the Government and issued by the Bureau of Standards, Washington, D.C., or any other Government agency can be purchased from the Superintendent of Documents, Washington, D.C.

Alum (sulphate for water purification):

American Water Works Association,
29 W. 39th St., New York, N.Y.

*American Railway Engineers Association,
59 E. Van Buren St., Chicago, Ill.
No. W.S.C. 4, 1922.

*American Railway Association, Circ. IV-39, 1924.

Missouri, Kansas & Texas Lines, 954-22.

Toledo City, Ohio, Dept. of Pub. Service,
Div. of Water.

Miscellaneous:

Corps of Engineers, War Department, Washington,
42.2-96, 1921 - powdered, for photoengravers' use.

Dept. of Purchase, New York City, N.Y.
10-A-80, 1915 - technical.
10-A-91, 1915 - reagent.
10-A-92, 1915 - filter alum.
10-A-81, 1915 - aluminum ammonium sulphate, reagent.
10-A-82, 1915 - aluminum ammonium sulphate, technical.

When crystallized alums are heated, the water of crystallization, and usually a little of the sulphuric acid is driven off, and the material falls to a white powder known as "burnt alum", which is used in pharmacy.

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Chromium-potassium sulphate is the best-known alum, in which aluminum has been replaced by another metal. Chrome alum, $K_2SO_4.Cr_2(SO_4)_3.24H_2O$, dark, violet-red crystals with specific gravity 1.81278, is soluble in water. It is derived by reducing potassium bichromate in dilute sulphuric acid with sulphurous acid. It is used for tanning and in photography as a fixing or hardening bath, also in ceramics and the textile industry.

USES AND SUBSTITUTES

Aluminum sulphate and the alums owe their value to the content of aluminum oxide, which is nearly 50 percent greater in the former than in the latter. Uses are based principally on the action of colloidal alumina on other colloids. Aluminum sulphate, which is considerably more economical to use, is replacing the alums to a large extent. About 75 pounds of the sulphate will do the work of 100 pounds of true alum.

The ancients used alum for medicine , as a mordant in dyeing, calico-printing, and tanning, and for inhibiting the combustibility of wood and wooden buildings. The Turks used it as a base for their magnificent Turkey red. The Romans, and the Egyptians at a much earlier period, prepared a soft, flexible leather by alum tannage.

At present alum is used extensively in the clarification of water and sewage and as a mordant in the dyeing industries. It is employed also in the manufacture of lake pigments, in the dressing of skins (tawing) to produce white leather, in sizing paper, in the production of fireproofing materials, and in medicine.

In water purification, a small amount of the gelatinous precipitate of aluminum hydroxide serves to coagulate the suspended matter into larger particles. These larger particles, which absorb also the greater part of the bacteria, settle rapidly, and the process therefore permits the use of relatively small settling ponds. Aluminum sulphate, or aluminoferric, and lime are added to the water (if the water has much temporary hardness, lime is not required). The amount of aluminum sulphate used depends upon the turbidity of the raw water or the relative amount of suspended matter to be removed. Crude ferrous sulphate, copperas, is often used instead of alum, being cheaper in many places. Other coagulants include ferric chloride and ferric sulphate and sodium aluminate - each involving questions of geographical location, price, and chemical behavior.

The Department of Agriculture experimented with aluminum sulphate for treatment of over-irrigated lands to put the ground in shape for further planting. Both aluminum-magnesium sulphate (pickeringite), occurring on the south bank of the Lahontan Reservoir, Fallon, Nev., and commercial aluminum sulphate were used but neither proved satisfactory economically.

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Paper makers use aluminum sulphate in sizing paper to precipitate aluminum resinate on the cellulose fibers to make the paper less water-absorbent. Between 30 and 35 percent of the aluminum sulphate produced in this country is thus used.

In dyeing cloth, the cloth is first soaked in a solution of alum or aluminum salt (mordant) and then steamed, so as to decompose the alum, before being steeped in the dye, which is absorbed and held or "fixed" by the aluminum oxide, which has been thoroughly incorporated in the fiber in the course of the preliminary treatment.

Sodium-aluminum sulphate was put on the market in 1892. It is used as an acid-reacting material in baking powder. Originally used alone for this purpose, it is now supplemented by calcium acid phosphate.

Aluminum sulphate and alum are also used in the foam type of fire extinguishers, which are suitable for extinguishing all types of oil fire. Most foam extinguishers resemble the acid-soda type in appearance.

In the dressing of furs (when tawing replaces the more expensive oil-tanning process) the skins are "fleshed", and the flesh side is coated with a paste of egg yolk and flour, to which aluminum sulphate or potash alum and common salt are added. This treatment is followed by drying and "ageing", which requires several weeks. The skins are then washed to remove the salt, again treated with egg yolk and flour, and allowed to dry.

Alums are used also in the manufacture of wood pulps, boiler compounds, glue and gelatin, oilcloth, linoleum, matches, margarine, ink, ceramics, in the rubber industry, catalyst in manufacture of ethane and ammonia, as a waterproofing agent for fabric, concrete, and porous brickwork, in explosives manufacture, agricultural spray material, engraving, photographic industry, sugar refining, manufacture of cucumber pickles, preparation of maraschino cherries, confectionery, hardening of plaster of Paris, and the treatment of silk stockings. Ammonia alum for filling the space between walls of fireproof safes has been largely superseded by less expensive materials.

The annual consumption of all kinds of alums and aluminum sulphate for all purposes in the United States has been estimated at 350,000 short tons (1929).

ALUMINUM SULPHATE MINERALS

Saline residues found when natural water is evaporated often contains sulphate of alumina. Mineral wells and springs that emerge from beds of pyritiferous shale may be rendered astringent by salts of aluminum. An alum well at Versailles, Mo., contains 7.36 percent aluminum, 76.57 percent SO_4, and smaller amounts of other elements. Such waters at times form local deposits of alum, generally as incrustations. Acid solutions acting upon aluminous rocks likewise may form sulphates of alumina, such as alunite and alunogen.

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Apjohnite occurs in white or yellowish silky or asbestiform masses and tastes like ordinary alum. It has been found in the "alum cave" of Sevier County, Tenn., in an open place under a shelving rock. The slates around and above this contain much pyrites in fine particles and even in rough layers. The salts form above and are brought down by trickling streams of water.

Kalinite, a natural potash alum, occurs as an incrustation or efflorescence on weathered shales, schists, or volcanic rocks and is recovered by leaching the weathered rock with water. Weathering can be accelerated by roasting or by adding sulphuric acid, and, if the natural rock does not contain enough potassium to form potassium alum, the necessary potassium is added as the sulphate.5/

Kalinite (potassium alum) associated with sulphur in rhyolite occurs in Esmeralda County, Nev. The alum is in an irregular network of veins. When the alum becomes exposed to the air, it crumbles to a white powder. Duncan6/ states that 100,000 tons of ore have been blocked out and that the probable tonnage is over 1,000,000 tons. An alum-recovery plant was in operation between 1920 and 1923. The ore was crushed to 3/4 inch, ground to 80- to 100-mesh, leached by a countercurrent method, and the alum solution filtered and crystallized. A detailed flow sheet of the process is presented in the Duncan article.

The daily capacity of the plant was 10 tons of C.P. alum and 10 tons of 85-percent sulphur concentrates. Analysis of run-of-mine ore is tabulated below:

	Percent
$K_2Al_2(SO_4)_4.24H_2O$	20.0
S (free)	15.0
SiO_2	58.8
Al_2O_3	2.6
$CaSO_4$	2.1
$CaCO_3$	1.2
F_2O_3	0.3
	100.0

Noncommercial deposits of kalinite occur in Jefferson and Larimer Counties, Colo.

Pickeringite and halotrichite are found in Colorado.

5/ Johnson, B. L., Potash: Ec. Paper 16, Bureau of Mines, 1933, p. 18.
6/ Duncan, Lindsay, Recovery of Potash Alum and Sulphur at Tonopah: Chem. Met. Eng., vol. 124, no. 12, Mar. 23, 1921, pp. 529-530. Also, Spurr, J. E., Alum Deposit Near Silver Peak, Esmeralda County, Nev.: U.S. Geol. Survey, Bull. 225, 1904, pp. 501-502.

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Alunogen is sometimes classified as an alum mineral. It is a hydrous aluminum sulphate ($Al_2(SO_4)_3.18H_2O$) relatively free from iron and is probably the "mountain butter" of the German mineralogists. The hardness ranges from 1.5 to 2, and the specific gravity is 1.6 to 1.8. It occurs in nature (like halotrichite) as a product of sublimation in volcanic regions and as a product of weathering of iron pyrites in the presence of aluminous shales. Occurrences are reported at Smoky Mountain, N.C.; and surface accumulations amounting to probably thousands of tons in Grant County, on the Gila River, 7/ about 27 miles north of Silver City, N.Mex.; also in Crook and Freemont Counties, Wyo., and Doughty Springs and Alum Gulch, Colo. Occurrences are reported abroad in Schemnitz, Hungary, in Japan, and in a number of places in New South Wales, Australia. It is not produced commercially at present but may be a potential source of alums.

Alum-shale is a rock of varying degrees of hardness, grayish bluish or iron-black color, often with a glossy or shining luster. It exhibits efflorescences and is composed chiefly of clay (silicate of alumina) with variable proportions of iron sulphides (pyrites), lime, bitumen, and magnesia. The pyrite or marcasite oxidizes and gives rise to the formation of aluminum sulphates or alums.

The composition of alum shale near Whitby and Redcar, England, used for alum, is given below: 8/

Constituents	Percent
Iron sulphide	8.50
Silica	51.16
Iron oxides	6.11
Alumina	18.30
Lime	2.15
Magnesia	.90
Sulphuric acid	2.50
Potash	Trace
Soda	do.
Carbon	8.29
Water	2.00
Total	99.91

The schist and shales of Whitby, England, were quite an important source of alum for more than 2 centuries.

7/ Hayes, C. W., The Gila River Alum Deposits, U.S. Geol. Survey Bull. 315, Government Printing Office, 1907, pp. 215-223.

8/ Merrill, George P., The Nonmetallic Minerals, Their Occurrence and Uses: 2d ed., revised, John Wiley & Sons, New York, p. 359.

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From 90 to 130 tons of schist were required to produce 1 ton of alum found in British commerce during the last century. The schist was subjected to slow combustion in very large heaps over a period of about 1 year. The pyrites gradually oxidized, with the production of sulphuric acid and the formation of iron and aluminum sulphates. The material was then leached in large stone or brick tanks, and the liquor settled, concentrated by heating, and excess iron crystallized out as copperas. Potash salt was added, and the alum first obtained recrystallized to purify it. Such deposits were worked in England for years.

Minerals

The known native alums are:

Kalinite (common alum)	$K_2SO_4.Al_2(SO_4)_3 + 24H_2O$.
Mendozite (soda alum)	$Na_2SO_4.Al_2(SO_4)_3 + 24H_2O$.
Pickeringite	$MgSO_4.Al_2(SO_4)_3 + 22H_2O$.
Apjohnite	$MnSO_4.Al_2(SO_4)_3 + 24H_2O$.
Bushmanite	$(Mn,Mg)SO_4.Al_2(SO_4)_3 + 24H_2O$.
Halotrichite	$FeSO_4.Al_2(SO_4)_3 + 24H_2O$.
Tschermigite (ammonium alum)	$(NH_4)_2SO_4.Al_2(SO_4)_3 + 24H_2O$.

There are also the closely related double sulphates, as follows:

Aromite	$6MgSO_4.Al_2(SO_4)_3 + 54H_2O$.
Dumreicherite	$4MgSO_4.Al_2(SO_4)_3 + 36H_2O$.
Sonomaite	$3MgSO_4.Al_2(SO_4)_3 + 33H_2O$.
Picroallumogene	$2MgSO_4.Al_2(SO_4)_3 + 22H_2O$.
Tamarugite	$Na_2SO_4.Al_2(SO_4)_3 + 12H_2O$.
Dietrichite, Mon.	$(Zn,Fe,Mn)SO_4.Al_2(SO_4)_3 + 22H_2O$.
Kronkite, Mon.	$CuSO_4.Na_2SO_4 + 2H_2O$.
Phillipite	$CuSO_4.Fe_2(SO_4)_3 + nH_2O$.
Ferronatrite	$3\ Na_2SO_4.Fe_2(SO_4)_3 + 6H_2O$.
Romerite	$FeSO_4.Fe_2(SO_4)_3 + 12H_2O$.

OTHER ALUMINOUS RAW MATERIALS

The alums of commerce are produced principally by acid extraction from bauxite, but they have also been made on a substantial scale from cryolite, clay, pyritic slates, schists, lignites, alunite, and leucite.

Bauxite is not a distinct mineral but a mixture of mineral substances. Broadly speaking, rock in place that has been weathered and leached is called laterite; but if it is sufficiently free from silica and if alumina predominates over other metal oxides, it is called bauxite. Bauxite is relatively rare compared with the vast quantities of low-grade aluminous material available.

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Typical bauxites now worked throughout the world contain less than 2 percent silica, 10 to 30 percent combined water, 55 to 65 percent alumina, and 25 to less than 1 percent ferric oxide, together with 1 to 2 percent titanium oxide. Bauxites of the United States and the Guianas are characterized by very high percentages of water, usually about 30 percent; by a low percentage of ferric oxide, usually about 1 percent; and by relatively high silica, usually about 2 percent. The alumina averages about 60 percent in the ores of the United States and somewhat higher in the ores of Guiana.

Fox[9/] has brought together a mass of information regarding bauxite.

Leucite ($K_2O.Al_2O_3.4SiO_2$) is a colorless to white or gray vitreous-looking potassium aluminum silicate occurring in igneous rocks, especially lavas, in crystals, varying from 3 inches in diameter to microscopic dimensions or round grains.

Alunite (alumstone or alum rock) is a native sulphate of aluminum and potassium, having the formula $Al_2(SO_4)_3.K_2SO_4.4Al(OH)_3$., and occurs both massive and in rhombohedral crystals (resembling cubes) in connection with volcanic rocks. It is white, with a vitreous luster, a hardness varying from 3.5 to 4, and a specific gravity of about 2.6.

Alunite from the mines at Tolfa, Italy, varies considerably in composition. The crystallized variety contains about 32 percent alumina, whereas the cruder specimens, which contain a large quantity of silica, have only about 17.5 percent. The following is an analysis of an average sample:[10/]

Constituents	Percent
Alumina	27.60
Sulphuric acid	29.74
Potash	7.55
Water	11.20
Iron	1.20
Silica	22.71
	100.00

In Australia several varieties of alunite are used for alum. One is light pink and contains 1.7 percent silica; another is a chalk-white, containing 16.4 percent silica; still another is purple, containing 19.5 percent silica; and a granular variety contains 39.5 percent silica. The origin is regarded as that of an alteration product of rhyolite, which was attacked by sulphurous fumes following an intrusion of dolerite.

9/ Fox, Cyril S., Bauxite and Aluminous Laterite: London, 1932.
10/ Merrill, George P., The Nonmetallic Minerals, pp. 355-357.

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Alunite occurs at Marysvale, Piute County, Utah, in veins requiring expensive development and underground mining; reserves are estimated at 3,000,000 tons.[11] Butler and Gale[12] describe these alunite deposits in detail. Other deposits occur in Beaver County and Tushar Mountains, Utah; Colorado; Nevada; California; Arizona; and Grant County, N.Mex.; also in Spain, Hungary, France, and Greece.

Alum may be produced from galafatite, similar in composition to alunite found near Benahabux, which is about 6 miles from the port of Almeria, Spain. The ore is calcined and washed in water. Its composition is as follows: SO_3, 77 percent; Al_2O_3, 37.98 percent; K_2O, 9.64 percent; H_2O, 17.61 percent.[13]

Cryolite, a fluoride of sodium and alumina, $3NaF.AlF_3$, when pure should contain 12.8 percent aluminum, 32.8 percent sodium, and 54.4 percent fluorine. The only known commercial deposit of cryolite is at Ivigtut, Greenland. The deposits and methods of mining them have been described by Gordon.[14]

By calcining cryolite with powdered limestone and leaching, or by boiling cryolite with water and lime, sodium aluminate is obtained as one of the products of the reaction, and this may be converted into concentrated alum with sulphuric acid. Aluminum sulphate may be obtained also by treating direct with sulphuric acid. One ton of cryolite produces three tons of alum. Cheaper sources of other materials have practically replaced cryolite for alum. Most of the cryolite shipped to the United States is used in the metallurgy of aluminum and in making opaque glass.

In England, aluminum shales from coal measures were substituted for the schists in 1845. These shales contained more alumina, less iron, and some potash and required less material to be mined, and the time required for the process was only a couple of months; consequently, the old method died out.

The shale was piled in heaps about 20 feet long, 4 or 5 feet high, and 2 or 3 feet wide. To supply air during calcination of the shale, a brick drain was constructed under each heap. After calcining, the material was removed to lead-lined cast-iron pans and treated with sulphuric acid. This mixture was heated and ammonia gas introduced. The liquor was then drawn off into lead lined vessels and agitated, after which the small crystals were removed, washed, broken, dissolved by steaming, and tapped off into crystallizing vats. After 40 days, the sides of the vats were removed and the 4-ton block of alum allowed to stand 2 weeks, after which a hole was made in the block to permit

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11/ Thoenen, J. R., Economics of Potash Recovery from Wyomingite and Alunite: Rept. of Investigations 3190, Bureau of Mines, November 1932, 78 pp.

12/ Butler, B. S., and Gale, H. S., Alunite, a Newly Discovered Deposit Near Marysvale, Utah: U.S. Geol. Survey Bull. 511, 1912, 64 pp.

13/ Butler, B. S., and Gale, H. S., Work cited.

14/ Gordon, S. G., Mining Cryolite in Greenland: Eng. and Min. Jour.-Press, vol. 121, Feb. 6, 1926, pp. 236-240.

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the mother liquor (1 ton) to run off. In addition to the time required to mine, the recovery process apparently required more than 2 months to prepare the raw material for market.

For a time the Pendleton Alum Works, England, using coal-measure shales, was the largest manufacturer of alum in the world, producing about 150 tons weekly in 1875.

Lignite.- During the last century, large deposits of lignite in Aisne, France, were worked and yielded 2,500 to 3,000 tons of alum annually. The 6- to 10-foot pyritic lignite deposits are overlain with clay, sand, and gravel. The deposits, more or less mixed with sand and clay, vary considerably in composition - 8 to 30 percent pyrite, 20 to 30 percent organic matter; and a large proportion of clay and iron oxide. Some lignite of this class contains 5.24 to 18.73 percent alumina.

In working the deposits, the top soil was removed and the lignite taken out by open-cast mining. By burning heaps of the material in the open, a red ash was obtained, which was rich in aluminum sulphate. This was leached out and ammonia added to produce ammonia alum. Ferrous sulphate was made as a joint product.

Alum can be made from a naturally occurring mineral phosphate consisting of alumina and a varying percentage of iron phosphate found in the island of Redonda, West Indies.

Miscellaneous sources.- Many processes for treatment of various substances such as potash feldspars, iron-free talc, greensand, mixtures of mica and potash salts, or clay and alkali sulphate with sulphuric acid, to produce aluminum sulphate or alum, are described in detail in "The Aluminum Industry", by Edwards, Frary, and Jeffries.

HISTORY

Alum was used by the ancient Greeks, Romans, and Egyptians, and Pliny noted its use as a mordant for the production of bright colors. In the 13th century, at Smyrna, it was produced from alunite or alum rock. The process of preparing it from pyritic shale has long been known. It appears to have been introduced into Europe in the 13th century, and during the 15th century several alum works were established. In 1460, John di Castro began producing alum at the La Tolfa works near Civitavecchia, Italy, a district in which alum ranked as an important product until recently. The product from these works, known as Roman alum, was, in former times, highly valued on account of its great purity; in fact, a statue was erected to the discoverer. This alum is characteristically stained orange red by finely divided ferric oxide.

In earlier times, alum was chiefly a natural product and even the ancients learned to remove, as being of best quality, the fine effloresecing crystals that first appeared. It was produced in Spain, Egypt, Armenia, Macedonia, Pontus, and Africa, and the islands Sardinia, Melos, Lipari, and Stromboli.

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The best came from Egypt. Phocis and Lesbos were able to supply the Turks with alum for their magnificent Turkey red. It was also made at Foya, Nova, near Smyrna, and at Constantinople. The trading people of Italy imported alum into Western Europe for the use of dyers of red cloth. At one time it was a monopoly of the papal powers, and it was one of the British Crown monopolies in the 16th and 17th centuries.

From Italy production was transferred to Spain near Cartagena. Germany began to produce it in 1554. The first known establishment there was at Oberkaufungen in Hesse.15/

Thomas Chaloner began the preparation of alum from schists on his Yorkshire (England) estate in 1600, and the same method of recovery was used on the Lias schists and material from the base of Carboniferous limestone series of Scotland down to the middle of the last century. Similar deposits have been worked for alum for centuries on the European Continent. Usually the acid employed for the extraction of the alumina was developed by roasting pyrites mixed with clay or shale. Because it was easiest to purify, principally potash alum was made at first. The manufacture of other aluminum compounds began to be important in the 19th century. In 1844, at the Paris Industrial Exposition, aluminum sulphate developed from clay was exhibited as a substitute for potash alum.

In time the manufacturers' methods were improved until, in 1858, a method was discovered for making aluminum sulphate containing 14 percent alumina from Passau clay. In 1866, "iron-free" aluminum sulphate, which was said to be entirely iron free and to contain 16 percent alumina, appeared in the market. It was made in England by the action of sulphuric acid on Irish bauxite or on Eglinton clay. In a number of factories, methods of purifying the aluminum sulphate solutions had been developed that were sufficiently effective. About that time, however, the process of making both soda and iron-free alumina from cryolite was developed. This process was so much more efficient than the methods in use for making pure aluminum sulphate that cryolite displaced the others, to be, in turn, displaced by bauxite.

Natural occurrences of alum were sought by the colonists in the new world. In 1651, Connecticut granted John Winthrop, Jr., a monopoly for working alum. Accounts of the first settlements made in Howard County, Mo., in 1805 mention alum deposits along with important mineral discoveries, such as those of iron, lead, copper, zinc, sulphur, copperas, saltpeter, and silver.

In 1815, alum was being produced commercially in this country on the Magothy River, Anne Arundel County, Md., by an organization with which was associated Girard Troost, an eminent mineralogist and crystallographer.

15/ Hunt, Robert, and Rudler, F. W., Ure's Dictionary of Arts, Manufactures, and Mines: 7th ed., London, 1875, vol. I, pp. 105-106.

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The importance of alum in these early days is apparent from tariff acts. By 1816, it received special mention and was given protection to the extent of $1.00 a hundredweight; the duty was increased to $2.50 a hundredweight in 1824.

Potash and ammonia alums were made by Charles Lennig, of Philadelphia, in 1837, and concentrated alum was made in 1859. The manufacture of crystal alum was begun by Harrison Bros. & Co., Philadelphia, about 1840, and it began the manufacture of concentrated alum from bauxite in 1877. The Pennsylvania Salt Manufacturing Co. began to manufacture concentrated alum at Natrona, Pa., in 1876 and was the first to manufacture porous alum.

METHODS OF PRODUCTION FROM BAUXITE

Bauxite, the principal source of alum in the United States, is mined in Arkansas, Georgia, Alabama, and Tennessee.

When bauxite is used for alum, the process consists in decomposing the mineral with sulphuric acid. An apparatus by which sulphuric acid and bauxite are delivered continuously at one end of the system, with a liquid overflow at the other end ready for evaporation, has been adopted in the last few years. A flow sheet illustrating this is shown in figure 1.

Best results are obtained by continuous 24-hour operation. One man per shift takes care of flow adjustment and control tests. Unloading from cars is on a per day basis. Reducing to 200 mesh is a 1-man, 8-hour per day job. Evaporating and removing from the cooling pan requires 3 men in 24 hours. Grinding, bagging and loading finished product is a day-shift job requiring 6 men. One fireman per shift takes care of two 250-horsepower boilers. Coal consumption is 0.30 lb. to 0.34 lb. per pound of alum.

Aluminum sulphate for water-purification is manufactured directly from bauxite and sulphuric acid at the Columbus, Ohio, and Washington, D.C., water-purification plants. This process eliminates five distinct steps in the manufacture of aluminum sulphate and its preparation for use in water purification, namely, filtering, concentrating, crystallizing, grinding, and redissolving. It is estimated that a considerable saving in cost is made compared with the cost of using the solid aluminum sulphate and that even greater reductions in cost probably can be achieved by utilizing halloysite (clay) as a substitute for bauxite. The estimated cost of producing 1,000 tons of 17 percent Al_2O_3 alum in solution by this process is $10,493.50.16/

The Washington plant that uses the process requires bauxite containing 57 percent alumina, with a loss on ignition of not less than 29 percent and a

16/ Ellms, Joseph W., Water Purification: 2d ed., 1928, p. 331.

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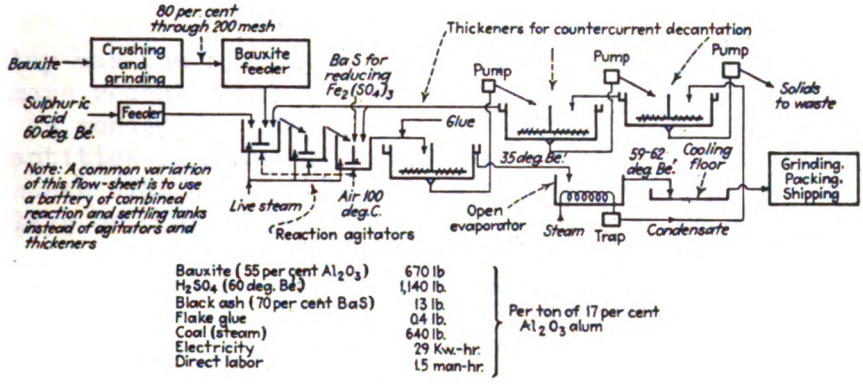

Figure 1.-Flow sheet of aluminum sulphate manufacturing process. (From Chem. and Met. Eng., vol. 41, no 5, May 1934, Editorial Supplement.)

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moisture content of not more than 1.5 percent; and, after being ground, the bauxite passing a 60-mesh sieve shall have an apparent density of more than 1. The total cost per ton of 17 percent alumina made at this plant in 1933 was $15.417.[17]

The cost of manufacturing a ton of alum from bauxite by the Kansas City (Mo.) Water Department, between April 21 and October 21, 1925, was $14.373. At Kansas City, Kans., 442 tons of alum were manufactured in 1924 at a cost of $18.68 per ton, somewhat higher than usual on account of a decreased use of alum. It should be borne in mind that both of these cities are near bauxite and sulphuric acid sources and benefit from lower transportation charges. The average value per ton of aluminum sulphate produced by municipal water works during the last 5 years (1930-34) was $16.20.

METHODS OF PRODUCTION FROM CLAY

In 1924, clay was the source of 5,180 tons of alum produced in the United States, but in more recent years the quantity probably has been less. A clay rich in alumina is needed for making aluminum salts. Some of these clays carry larger quantities of aluminum oxide than kaolin, notably those from central Missouri, where diaspore-bearing clays carrying over 50 percent alumina occur. These clays or clay mixtures are sold according to their alumina content, in three grades containing 55, 65, and 70 percent alumina (Al_2O_3). Ordinary clays at best contain but 30 to 40 percent alumina, usually less, as compared with a 60-percent alumina content for bauxite, and the efficiency of alumina extraction is usually greater for bauxite than for clay.

Sulphuric acid decomposition of clay is now the standard operation in preparing aluminum sulphate for water purification. It is not a difficult operation and requires only agitation and time and very little heating. Previous practice has involved heating the mixture of clay and sulphuric acid more than was necessary.

The necessity for destroying organic matter is restricted to clays and shales. Organic matter, like humas, causes settling and filtration difficulties during leaching. If the organic matter is not destroyed, it goes with the solution, becomes charred from the action of the acids and heat, and appears in the final product, coloring it gray or brown.[18]

Kaolin or china clay resulting from decomposed feldspar and approximating the formula $Al_2O_3 2SiO_2$, 2 H_2O, found in Cornwall, England, has been used for the manufacture of aluminum sulphate. The clay, containing about 40 percent alumina, is selected as free as possible from grit and iron oxide, dried, screened, and calcined in a reverberatory furnace. It is then treated with

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17/ Lauter, Carl J., Manufacture of Aluminum Sulphate at the Dalecarlia Filter Plant, Washington, D.C.: Ind. and Eng. Chem., vol. 25, no. 29, September 1933, pp. 953-958. Easton, Pa.

18/ Tilley, G. S., Millar, R. W., Ralston, O. C., Acid Processes for the Extraction of Alumina: Bull. 267, Bureau of Mines, 1927, pp. 8 and 82.

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sulphuric acid, producing alum cake. (About 60 percent of the alumina is converted into sulphate.) Commercial white sulphate of alumina is prepared from alum cake.

In France, kaolins were calcined at low red heat in a furnace, ground to a powder in a mill, mixed with sulphuric acid, and heated in another furnace. After the sulphuric acid began to evaporate, the residue was taken out and left to stand for several days. The sulphate of alumina was removed and potash or ammonia salt added.

BYPRODUCT SOURCES

Leucite mined in Italy has been shipped to an alum plant at Pierre Benite, near Lyons, France. The plant yields 6 tons of alum daily, requiring 4 tons of leucite. The ground leucite (meal or grain) is treated with sulphuric acid, in which its alumina and potash are soluble; and the solution, which already contains these oxides in almost equimolecular ratio, is crystallized and purified. Hinchley[19] gave costs of manufacture at this plant as 31 centimes per kilogram for alum, with sulphuric acid at 22 centimes per kilogram; or, in English equivalents, with acid at £3 per ton the cost of production of alum is £4 4s. per ton, on the basis of an 80-percent yield of the alumina contained in the leucite. The leucite deposits in Sweetwater County, Wyo., up to the present have not been utilized commercially as a source of the alums.

In preparing alum from alunite, the ore is first hand-sorted, roasted or calcined in kilns, and subsequently weathered. The calcined alum-stones piled in heaps 2 to 3 feet high are exposed to the weather and kept moist by sprinkling them with water. As the water combines with the alum, the stones crumble and fall eventually into a pasty mass, which must be leached with warm water and allowed to settle in a large cistern. The liquor is drawn off, evaporated, and then crystallized. A second crystallization finishes the process, which produces a marketable alum. One ton of alunite supplies about 14 to 16 cwt. of alum, sometimes more, and about 2 tons of aluminum sulphate containing 15 percent Al_2O_3.

A once important alunite deposit occurs at Bullah-Delah, New South Wales, Australia. It yields about 80 percent alum. Since 1908 it has been shipped to England for treatment. The output, which was 1,024 tons in 1924, dwindled to only 39 tons in 1929.

DOMESTIC PRODUCTION

Alum has been made in this country from clay, bauxite, cryolite, and kalinite. Although native alums occur at a number of points in the United

19/ Hinchley, J. W., The Manufacture of Potash and Other Salts from Leucite: Chem. and Ind. Rev., Jour. Soc. Chem. Ind., London, vol. 43, 1924, p. 162.

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States, they have been utilized to a limited extent only. About 140,000 tons of bauxite, a large part of which is imported, is used to produce alums and other aluminum salts.

Alum was being produced commercially in the United States in 1815; before then it appears to have been more profitable to make it abroad and import it. Alum-making as an American industry probably got its real start during the War of 1812, when we were cut off from foreign supplies.

Alum making from bauxite began in 1877. In 1880, there were six establishments that reported to the Census Bureau the production of 19,600 tons of alums valued at $808,165. There are no previous statistics, and prior to the census of 1900 the various alums were not reported separately. In 1900, concerns reporting to Census Bureau produced 91,500 short tons valued at $2,500,000 (37,400 tons of alums and 54,100 tons of aluminum sulphate). A tremendous increase in output of aluminum sulphate has taken place since the peak of about 347,000 tons was reached in 1929. The output of alums, on the other hand, has declined, production in 1929 having amounted to only 26,900 tons. Production and shipments in recent years are shown in the following tabulations:

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Alums and aluminum sulphate produced in the United States, shipped in 1929 to 1934

	Alum				Aluminum sulphate			Total
	Ammonia	Potash	Other	Sodium aluminum sulphate	Commercial: General	Commercial: Municipal	Iron-free	
1929								
Number of producers reporting	5	3	1	3	11	6	6	
Short tons	5,108	6,304	1/	15,005	319,736	8,190	20,441	374,784
Total value	$286,592	$254,290	1/	$855,754	$7,589,244	$126,550	$731,732	$9,844,162
Average value	$56	$40	1/	$57	$24	$15	$36	
1930								
Number of producers reporting	5	3	-	3	10	9	7	
Short tons	4,076	1,923	-	14,787	305,059	10,300	18,177	354,322
Total value	$228,986	$104,818	-	$802,981	$6,649,066	$172,671	$642,247	$8,600,769
Average value	$56	$55	-	$54	$22	$17	$35	
1931								
Number of producers reporting	5	3	-	3	10	10	7	
Short tons	4,668	2,086	-	15,907	291,875	11,509	15,108	341,153
Total value	$251,066	$111,168	-	$905,184	$5,951,392	$193,450	$483,060	$7,895,320
Average value	$54	$53	-	$57	$20	$17	$32	
1932								
Number of producers reporting	5	3	-	3	11	10	7	
Short tons	3,889	2,098	-	16,341	261,254	10,954	14,017	308,553
Total value	$202,216	$108,345	-	$888,607	$5,309,149	$165,905	$428,523	$7,102,745
Average value	$52	$52	-	$54	$20	$15	$31	
1933								
Number of producers reporting	5	3	-	3	11	10	7	
Short tons	4,039	1,869	-	18,750	305,001	9,696	15,142	354,497
Total value	$205,791	$95,792	-	$1,022,345	$6,077,410	$147,716	$465,769	$8,014,823
Average value	$51	$51	-	$55	$20	$15	$31	
1934								
Number of producers reporting	5	3	1	3	11	10	7	
Short tons	4,859	2,869	1/	17,767	306,532	10,227	14,653	356,907
Total value	$240,466	$145,674	1/	$967,766	$6,091,284	$170,674	$463,140	$8,079,004
Average value	$49	$51	1/	$54	$20	$17	$32	

1/ Included under potash.

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The following table shows the recent record of actual production, to indicate the difference between these figures and those for shipments shown in the preceding table:

Alum and aluminum sulphate produced in the United States, 1929 to 1934, in short tons

Salt	1929	1930	1931	1932	1933	1934
Alum:						
Ammonia	5,712	4,489	4,085	4,032	4,156	4,739
Potash	) 6,235	1,984	2,404	1,198	1,858	(3,003
Other	)	---	---	---	---	(
Sodium-aluminum sulphate	14,947	14,776	15,945	16,428	18,941	17,742
Aluminum sulphate:						
Commercial	326,549	314,870	299,864	271,537	316,608	317,535
Iron-free	20,181	23,217	14,636	14,029	16,016	14,852
Total	373,624	359,336	336,934	307,224	357,579	357,871

IMPORTS

Imports of the low-grade alumina sulphate containing not over 15 percent alumina have come entirely from Germany and France in recent years.

The exporting countries and their relative importance in terms of quantity and value of high-grade aluminum sulphate shipped containing more than 15 percent alumina and not more iron than equivalent to 0.1 percent ferric oxide are shown in the following table. In 1933, in addition to the countries tabulated, Sweden sent 13,228 pounds of aluminum sulphate, valued at $109, and Canada 32,000 pounds valued at $330, thus together contributing 10.9 percent of total imports. The most significant point brought out by the table is the relative decline in position of Germany as compared with that of the United Kingdom and Belgium. Imports from the Netherlands probably represent reexports of the German or Belgium product.

Imports of alums are not large. They are included in the tabulation of domestic consumption.

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Principal sources, quantity, and value of imports of aluminum sulphate (containing more than 15 percent alumina or not more iron than 1/10 percent ferric oxide)

	1923	1925	1927	1929	1931	1932	1933	1934
Pounds:								
Germany.....	329,617	1,482,747	1,384,754	2,389,715	820,209	577,185	122,366	---
Netherlands.....	135,046	57,119	---	---	1,106,712	2,679	1,323	---
United Kingdom...	46,580	10,988	---	59,041	10,803	38,416	49,236	22,722
Belgium.....	---	57,119	22,081	50,926	19,820	95,205	196,761	742,179
All other.....	33	---	71,737	22,400	---	22,050	45,228	---
Total.....	511,276	1,607,973	1,478,572	2,522,082	1,957,544	735,535	414,914	764,901
Value:								
Germany.....	$4,561	$15,765	$14,428	$23,176	$7,697	$4,535	$908	---
Netherlands.....	2,461	607	---	---	12,047	74	36	---
United Kingdom...	1,025	175	---	1,122	136	447	640	$333
Belgium.....	---	699	200	592	172	798	1,352	5,270
All other.....	2	---	4,093	241	---	205	439	---
Total.....	8,049	17,246	18,721	25,131	20,052	6,059	3,375	5,603

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Imports by Grades

The predominant importance of the general grade containing more than 15 percent alumina or less iron than the equivalent of 0.1 percent ferric oxide is brought out by the following:

Imports of aluminum sulphate, by kinds

Year	Not over 15 percent alumina	Percentage of total	More than 15 percent alumina 1/	Percentage of total	Total imports
	Pounds		Pounds		Pounds
1923	194,793	27.6	511,276	72.4	706,069
1924	18,545	2.6	696,365	97.4	714,910
1925	104,625	6.1	1,607,973	93.9	1,712,598
1926	89,891	4.5	1,903,391	95.5	1,993,282
1927	54,194	3.5	1,478,572	96.5	1,532,766
1928	4,563	0.4	1,112,005	99.6	1,116,568
1929	3,090	0.1	2,522,082	99.9	2,525,172
1930	55,636	2.7	2,041,168	97.3	2,096,804
1931	1,025	0.1	1,957,544	99.9	1,958,569
1932	12,273	1.6	735,535	98.4	747,808
1933	---	---	414,914	100.0	414,914
1934	---	---	764,901	100.0	764,901

1/ Or less iron than equivalent to 0.1 percent ferric oxide.

Imports of aluminum sulphate, alum cake, or aluminous cake containing not over 15 percent of alumina and more iron than 1/10 percent of ferric oxide

Calendar year	Rate of duty	Quantity	Value	Unit value	Computed duty	Computed ad valorem rate
	Cents per lb.	Pounds				Percent
1923	3/10	194,793	$3,515	$0.018	$584	16.63
1924	Do.	18,545	345	.019	56	16.13
1925	Do.	104,625	1,505	.014	314	20.86
1926	Do.	89,891	1,087	.012	270	24.81
1927	Do.	54,194	715	.013	163	22.74
1928	Do.	4,563	332	.073	14	4.12
1929	Do.	3,090	425	.138	9	2.18
1930:						
Jan. 1-June 17	Do.	55,636	854	.015	167	19.54
June 18-Dec. 31	1/5	---	---	---	---	---
Total 1930	---	55,636	854	.015	167	19.54
1931	1/5	1,025	89	.087	2	2.25
1932	Do.	12,273	216	.018	25	11.57
1933	Do.	---	---	---	---	---
1934	Do.	---	---	---	---	---

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Imports of aluminum sulphate, alum cake, or aluminous cake containing more than 15 percent alumina or not more than 1/10 percent ferric oxide

Calendar year	Rate of duty	Quantity	Value	Unit value	Computed duty	Computed ad valorem rate
	Cents per lb.	Pounds				Percent
1923	3/8	511,276	$8,049	$0.016	$1,917	23.82
1924	Do.	696,365	9,045	.013	2,611	28.87
1925	Do.	1,607,973	17,246	.011	6,030	34.96
1926	Do.	1,903,391	19,769	.010	7,138	36.11
1927	Do.	1,478,572	18,721	.013	5,545	29.62
1928	Do.	1,112,005	11,098	.010	4,170	37.57
1929	Do.	2,522,082	25,131	.010	9,458	37.63
1930	Do.	2,041,168	19,628	.010	7,654	39.00
1931	Do.	1,957,544	20,052	.010	7,341	36.61
1932	Do.	735,535	6,059	.008	2,758	45.52
1933	Do.	414,914	3,375	.008	1,556	46.1
1934	Do.	764,901	5,603	.007	2,868	51.2

TARIFF HISTORY

Alum is first mentioned in the Tariff Act of 1816, when it received protection to the extent of $1.00 per hundredweight, which was increased to $2.50 in 1824. Aluminum sulphate is first mentioned in the Act of 1862, when the duty was 60¢ per 100 pounds. The Tariff Act of 1930 provided duties of 1/5¢ per pound on low-grade aluminum sulphate (with not over 15 percent alumina and not more iron than 1/10 of 1 percent ferric oxide) and 3/8¢ per pound on high-grade aluminum sulphate (over 15 percent alumina or not more iron than 1/10 of 1 percent ferric oxide). However, under the terms of the trade agreement with Belgium, effective May 1, 1935, the duty on imports of aluminum sulphate (except from Germany) is now 1/5¢ per pound on both grades. Under the Act of 1930, the duty on sodium alum is 25 percent, on ammonium alum 3/4¢, and on potash alum 3/4¢ per pound.

EXPORTS

Aluminum-sulphate exports go chiefly to Canada for use in the manufacture of paper. Virtually all of the remainder is taken by Latin American countries. The quantity of alums exported probably is not large, being included in the item "other aluminum compounds" and not shown separately in export-trade statistics.

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Aluminum sulphate exported from the United States, 1929-34

Year	Short tons	Value
1929.....	26,588	$607,757
1930.....	25,255	573,234
1931.....	27,668	568,490
1932.....	21,550	462,954
1933.....	28,270	543,945
1934.....	30,881	594,440

DOMESTIC CONSUMPTION

The apparent consumption of aluminum sulphate, which in the early years of the 1920's averaged about 230,000 tons, rose to 323,000 tons in 1929 but subsequently fell off, during the depression, to an average of about 293,600 tons yearly. The important use for aluminum sulphate is in connection with the purification of water, and 60 percent of the total production is said to be used for this purpose. Furthermore, there has been a steady growth in the quantity manufactured by municipal water works for their own use; thus, 15 years ago they manufactured an average of only 4,600 tons, but now they average 10,500 tons annually. Whereas only about 28 percent of the urban population in this country had treated water 25 years ago, today 85 percent of the urban population has it.

Paper making, which requires 30 to 35 percent of the aluminum sulphate produced, has grown until it reached the proportion of a $967,000,000 industry in 1929.

The consumption of alums averages 23,000 tons annually now, whereas the annual average in the early 20's was 14,000 tons, about 72 percent of which is soda alum, which has contributed largely to this increase. Sodium aluminum sulphate is used extensively in baking powders.

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The statistics for the past 15 years, tabulated below, reflect somewhat the fluctuations that have taken place in the requirements of industries using aluminum sulphate and alums, as well as the extent to which we are independent of foreign supplies.

Consumption of aluminum sulphates and alums in the industry, 1920-34

Aluminum Sulphate (Short Tons)

Year	Quantity shipped				Imports	Exports	Apparent consumption
	Commercial		Iron free	Total			
	General	Municipal					
1934	306,532	10,227	14,653	331,412	382	30,881	300,913
1933	305,001	9,696	15,142	329,839	202	28,270	301,771
1932	261,254	10,954	14,017	286,225	374	21,550	265,049
1931	291,875	11,509	15,108	318,492	978	27,668	291,802
1930	305,059	10,300	18,177	333,536	430	25,255	308,711
1929	319,736	8,190	20,441	348,367	1,263	26,588	323,042
1928	311,775	8,444	23,940	344,159	558	22,713	322,004
1927	309,400	6,810	20,210	336,420	766	21,128	316,058
1926	307,550	7,130	16,160	330,840	997	22,031	309,806
1925	276,210	6,240	16,140	298,590	856	20,756	278,690
1924	250,630	5,690	15,570	271,890	357	16,012	256,235
1923	246,095	4,303	16,007	266,405	353	17,805	248,953
1922	231,385	6,075	19,162	256,622	269	13,225	243,666
1921	151,859	3,060	11,003	165,922	--	--	165,922
1920	229,888	4,115	--	234,003	--	--	234,003

Ammonia Alum

Year	Quantity shipped	Imports	Apparent consumption
1934	4,859	--	4,859
1933	4,039	4	4,043
1932	3,889	7	3,896
1931	4,668	--	4,668
1930	4,076	--	4,076
1929	5,108	--	5,108
1928	5,018	86	5,104
1927	5,200	97	5,297
1926	4,560	76	4,636
1925	4,750	119	4,869
1924	4,920	97	5,017
1923	4,766	93	4,859
1922	8,305	6	8,311
1921	6,284	--	6,284
1920	--	--	--

(Continued on page 25)

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Potash Alum

Year	Quantity shipped	Imports	Apparent consumption
1934	2,869 1/	80	2,949
1933	1,869	531	2,400
1932	2,098	578	2,676
1931	2,086	303	2,389
1930	1,923 1/	328	2,251
1929	6,304 1/	371	6,675
1928	-- 2/	449	449
1927	--	790	790
1926	--	1,673	1,673
1925	--	1,897	1,897
1924	--	1,591	1,591
1923	--	1,178	1,178
1922	-- 2/	279	279
1921	26	--	26
1920	--	--	--

Soda Aluminum Sulphate (Shipments Only)

Year	Quantity shipped
1934	17,767
1933	18,750
1932	16,341
1931	15,907
1930	14,787
1929	15,005
1928	15,718
1927	14,230
1926	16,740
1925	14,450
1924	13,920
1923	2/
1922	9,506
1921	5,910
1920	--

1/ Includes plant reporting making other alum.
2/ Not reported separately.

MARKETS AND PRICES

At present the greater part of the production, as well as most of the consumption of alums and aluminum sulphate, is made east of the Mississippi River. It is important to consider this point in connection with any proposal to develop natural deposits of aluminous compounds, for the reason that charges for transportation to distant competitive markets are likely to prove prohibitive. Sales of these products for use in water purification depend upon the impurity of local water supplies, and it must be remembered, too,

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that more and more municipal water works produce their own sulphate. Trade channels are not complicated. Some business is handled by dealers, but consumers ordinarily buy direct from manufacturers, placing their orders principally in the fall.

Quotations on the alums and aluminum sulphate do not change suddenly but remain about the same from month to month for years. The present price of $1.90 per 100 pounds for iron-free aluminum sulphate, which is nominal, of course, has remained unchanged since 1931, and $1.35 for the commercial grade has not changed since 1933. For ammonia and potash alums, $3.00 has been quoted since the summer of 1933, while before then the price was $3.30 for several years. The price of sodium aluminum sulphate has been $4 per hundred pounds since July 1933; quotations since 1922 range from $3.25 to $4.00.

World War conditions naturally brought unsteady prices. For instance, on August 14, 1914, iron-free aluminum sulphate, which had been $1.25 to $1.75 per hundred pounds, rose to $1.50 to $2.00 by October 15 of that year, and 12 months later the price was up to $2.25 to $2.75, reaching the peak of $5 to $6.50 in April 1916. The commercial grade, which cost around 90¢ before 1914, reached a high of $4.50 in April 1916. Immediately after the war, prices settled down, only to rise again in the summer of 1920. They have been steady since, but gradually lower.

For years before 1914 ammonia alum was quoted at between $1.75 and $2.00 per hundred pounds, but the price rose rapidly during the war period to a maximum of $8.50 in 1918. Subsequently, the price declined to $3.00, which happens to be the present price of potash alum also. During the past 10 or 15 years, potash and ammonia alum prices have favored one or the other by only a fraction of a cent per pound; this was true, likewise, before 1914, although during the World War, due to the difficulty experienced in getting potash, potash alum prices skyrocketed to $12.00 per hundred pounds in 1918.

The tabulations of wholesale prices presented on page 27 are taken from the Oil, Paint and Drug Reporter and Industrial and Engineering Chemistry.

Those for ammonia and potash alum are quoted in the Oil, Paint and Drug Reporter for contract and open market, f.o.b. Philadelphia, freight equalized with Marcus Hook, Pa., Boston, Mass., Atlanta, Ga., and Joliet, Ill. Rail or water rate, whichever is lower, applies. Less-than-carload quantities must carry less-than-carlot rate applying. For truck or ex-warehouse deliveries to all metropolitan zones add the less-than-carlot rail or water rate, whichever is lower, from point of shipment or equalization to the metropolitan zone involved. The New York metropolitan zone is an exception to this rule prices delivered via truck or ex-warehouse applying there. In Mount Vernon and Yonkers, or points nearby thereto in Westchester County, lots of 25 barrels or over will be delivered via truck.

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Aluminum Sulphate (New York price per 100 Pounds)

Year	January		April		July		October	
	Commercial	Iron-free	Commercial	Iron-free	Commercial	Iron-free	Commercial	Iron-free
1910	$1.25-$2.00		$1.25-$2.00		$1.12½-$2.00		$0.90-$2.00	
1911	0.90-1.75		0.90-1.75		0.90-1.75		0.90-1.75	
1912	.90-1.75		.90-1.75		.90-1.75		.90-1.75	
1913	.90-1.25	1.25- 1.75	.90-1.25	1.40- 1.75	.90-1.25	1.40- 1.75	.90-1.25	1.25- 1.75
1914	.90-1.25	1.25- 1.75	.90-1.25	1.25- 1.75	.90-1.25	1.25- 1.75	1.10-1.30	1.50- 2.00
1915	1.10-1.30	1.30- 1.60	1.10-1.30	1.50- 1.75	1.10-1.30	1.25- 1.50	1.40-1.55	2.25- 2.75
1916	3.00-4.00	5.00- 5.25	4.00-4.50	5.00- 6.50	4.00-4.50	65.00-70.00 1/	4.00-4.50	70.00-90.00 1/
1917	2.00-2.50	60.00-70.00 1/	2.00-2.50	70.00-75.00 1/	2.00-2.50	75.00-80.00 1/	2.00-2.50	70.00-75.00 1/
1918	1.75-2.25	2.75- 3.00	2.50-3.00	3.25- 3.50	2.25-3.00	3.50- 4.00	2.00-3.50	4.00- 5.00
1919	2.00-2.75	4.50- 4.75	1.75-2.25	3.00- 3.25	1.60-2.00	3.00- 3.25	1.50-1.60	2.50- 2.75
1920	1.60-1.75	3.00	1.80-2.25	3.00	2.50-3.25	5.00	2.75-3.50	4.50
1921	2.50-2.75	3.50	2.25-2.50	3.00	1.60-2.50	3.00	1.60-2.00	3.00
1922	1.60-2.00	3.00	1.55-2.00	2.50	1.50-1.75	2.50	1.50-1.75	2.50
1923	1.50-1.60	2.50	1.50-1.60	2.50	1.40-1.60	2.50	1.40-1.60	2.50
1924	1.40-1.60	2.50	1.35-1.40	2.37½	1.35-1.40	2.37½	1.35-1.40	2.37½
1925	1.40	2.00	1.40	2.00	1.40	2.00	1.40	2.00
1926	1.40	2.00	1.40	2.00	1.40	1.75	1.40	1.75
1927	1.40	1.75	1.40	1.75	1.40	1.75	1.40	1.75
1928	1.40	1.75	1.40	1.75	1.40	1.75	1.40	1.75
1929	1.40	1.75	1.40	1.95	1.40	1.95	1.40	1.95
1930	1.40	1.95	1.40	1.95	1.40	1.95	1.40	1.95
1931	1.25	1.90	1.25	1.90	1.25	1.90	1.25	1.90
1932	1.25	1.90	1.25	1.90	1.25	1.90	1.25	1.90
1933	1.25	1.90	1.25	1.90	1.25	1.90	1.25	1.90
1934	1.35	1.90	1.35	1.90	1.35	1.90	1.35	1.90
1935	1.35	1.90	1.35	1.90	1.35	1.90	1.35	1.90

1/ Per ton.

(Continued on page 28)

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Ammonia Alum (New York price per 100 Pounds)

Year	January	April	July	October
1910	.....	.....	.....	.....
1911	$1.75-$2.00	$1.75-$2.00	$1.75-$2.00	$1.75-$2.00
1912	1.75- 2.00	1.75- 2.00	1.75- 2.00	1.75- 2.00
1913	1.75- 2.00	1.75- 2.00	1.75- 2.00	1.75- 2.00
1914	1.75- 2.00	1.75- 2.00	1.75- 2.00	2.75- 3.00
1915	2.75- 3.00	2.50- 3.00	3.25- 3.50	5.25- 5.50
1916	5.00- 5.25	4.25- 4.75	4.00	4.00- 4.25
1917	4.00- 4.25	4.00- 4.25	4.50- 4.75	4.25- 4.50
1918	4.00- 4.50	4.00- 4.50	4.75- 5.25	7.00
1919	7.00	5.00	4.25- 4.50	4.25- 4.50
1920	4.00	4.00	4.00	4.75
1921	4.75	4.25	3.50	3.50
1922	3.50	3.50	3.50	3.50
1923	3.50	3.50	3.25	3.50
1924	3.50	3.50	3.50	3.50
1925	3.40	3.40	3.40	3.15
1926	3.15	3.15	3.15	3.15
1927	3.15	3.15	3.15	3.15
1928	3.25	3.25	3.25	3.25
1929	3.25	3.25	3.25	3.25
1930	3.30	3.30	3.30	3.20
1931	3.30	3.30	3.30	3.30
1932	3.30	3.30	3.30	3.30
1933	3.30	3.30	3.00	3.00
1934	3.00	3.00	3.00	3.00
1935	3.00	3.00	3.00	3.00

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Potash Alum (New York price per 100 Pounds)

Year	January	April	July	October
1915	.....	.....	.....1/.....	.....1/.....
1916	$10.50	$11.00	$6.50-$7.00	$6.00-$6.25
1917	6.00- 6.25	5.75- 6.50	8.25	8.50- 8.75
1918	7.00- 8.00	8.00- 9.00	8.25- 9.25	11.50-12.00
1919	11.00- 12.00	8.00- 10.00	8.00-10.00	8.00-10.00
1920	8.00- 9.00	8.00- 9.00	7.75- 8.50	8.75- 9.25
1921	5.50- 6.00	5.50- 6.50	3.75- 4.25	3.75- 5.75
1922	3.50 2/	3.25 2/	3.00 2/	3.50 2/
1923	3.25 2/	3.25 2/	3.25 2/	3.25 2/
1924	3.00 2/	3.00 2/	3.00 2/	3.00 2/
1925	3.10	3.50	3.50	3.50
1926	3.50	3.50	3.50	3.50
1927	3.50	3.50	3.50	3.50
1928	3.10	3.10	3.10	3.10
1929	3.10	3.00	3.00	3.00
1930	3.20	3.20	3.10	3.30
1931	3.35	3.35	3.35	3.35
1932	3.35	3.35	3.35	3.35
1933	3.35	3.35	3.00	3.00
1934	3.00	3.00	3.00	3.00
1935	3.00	3.00	3.00	3.00

1/ No price because of scarcity.
2/ Resale or imported (not an American maker's price).

Soda Alum (Sodium Aluminum Sulphate) (New York price per 100 Pounds)

Year	January	April	July	October
1922	$3.50	$3.50	$3.50	$4.00
1923	4.00	4.00	4.00	4.00
1924	4.00	4.00	4.00	4.00
1925	4.00	3.50	3.50	3.50
1926	3.50	3.50	3.50	3.25
1927	3.25	3.25	3.25	3.25
1928	3.75	3.75	3.75	3.75
1929	3.75	3.75	3.75	3.75
1930	3.75	3.75	3.50	3.50
1931	3.45	3.45	3.45	3.45
1932	3.45	3.45	3.45	3.45
1933	3.45	3.45	4.00	4.00
1934	4.00	4.00	4.00	4.00
1935	4.00	4.00	4.00	4.00

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PRODUCERS

Water-Purification Plants in the United States Using Bauxite

Birmingham Water Works Co., Birmingham, Ala.
Board of Public Utilities, Kansas City, Kans.
Bureau of Water Supply, Baltimore, Md.
City of Columbus Purification Works, Columbus, Ohio.
Columbus Water Works, Columbus, Ga.
Dalecarlia Filter Plant, Washington, D.C.
Metropolitan Utilities District, Omaha, Nebr.
Passaic Valley Water Commission, 158 Ellison Street, Paterson, N.J.
Sacramento Filtration Works, Sacramento, Calif.
Water Department of Kansas City, Kansas City, Mo.

Consumers of Bauxite-Making Alums and Aluminum Sulphate

Bogalusa Paper Co., Bogalusa, La.
Brown Co., Berlin, N.H.
Calumet Chemical Co., Joliet, Ill.
General Chemical Co., 40 Rector St., New York, N.Y.
Grasselli Chemical Co., Cleveland, Ohio.
American Cyanamid & Chemical Corp., 535 5th Ave., New York, N.Y.
Charles Lennig & Co., Inc., 222 West Washington Square, Philadelphia, Pa.
Louisiana Chemical Co., Inc., Bastrop, La.
Merrimac Chemical Co., 148 State St., Boston, Mass.
Paper Makers Chemical Corp., Wilmington, Del.
Pennsylvania Salt Manufacturing Co., Widener Bldg., Philadelphia, Pa.
Stauffer Chemical Co., 624 California St., San Francisco, Calif.
Welch Chemical Co., 8 East Long St., Columbus, Ohio.

Bauxite Producers in the United States in 1934

American Cyanamid & Chemical Corp., 30 Rockefeller Plaza, New York, N.Y.
Crawford Bauxite Co., Bauxite, Ark.
Crouch Mining Co., Inc., P. O. Box 35, Bridge Station, Niagara Falls, N.Y.
Dixie Bauxite Co., Inc., Sweet Home, Ark.
Benjamin Easterlin, Americus, Ga.
Charles Lennig & Co., Inc., 222 West Washington Square, Philadelphia, Pa.
Republic Mining & Manufacturing Co., 230 Park Avenue, New York, N.Y.
Standard Bauxite & Chemical Co., Inc., Bauxite, Ark.

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BIBLIOGRAPHY

General

CLARKE, F. W. The data of geochemistry: U.S. Geol. Survey Bull. 770, 1924, pp. 260 and 551.
CONDENSED CHEMICAL DICTIONARY. Chemical Engineering Catalog Co., Inc., New York, 1930, p. 32.
CURTIS, F. G. Marketing alums and aluminum salts: Chem. and Met. Eng., November 1926, pp. 687-689.
DANA, JAMES D, and EDWARD S. A system of mineralogy. New York, 1911, pp. 951-956.
HESS, FRANK L. Glossary of mineral terms, U.S. Bureau of Mines. In preparation (1935).
LADOO, RAYMOND B. Nonmetallic minerals, occurrence, preparation, utilization. New York, 1925, 686 pp.
MELLOR, J. W. A comprehensive treatise on inorganic and theoretical chemistry, vol. V, Aluminum. New York, 1924, pp. 340-352.
MERRILL, G. P. The nonmetallic minerals, their occurrence and uses. New York, 1910, pp. 221-251 and 350-357.
PATTERSON, AUSTIN M. The history of the word alum: Ind. and Eng. Chem., vol. 18, no. 6, June 1926, p. 634.
THE ENCYCLOPEDIA AMERICANA, vol. 1. New York, 1927, pp. 453-454.
THE ENCYCLOPEDIA BRITANNICA, vol. 1, 14th ed. New York, 1929, pp. 712-713.
THORPE, EDWARD. A dictionary of applied chemistry, vol. 1. London, 1921, pp. 171 and 175.
WEBSTER'S NEW INTERNATIONAL DICTIONARY. 2d ed. Cambridge, Mass., 1935, p. 78.

Statistics

ALUMINUM AND BAUXITE chapters in volums of Mineral Resources of United States from 1901 to 1931 and Minerals Yearbook 1932-33-34.
MUNROE, CHARLES E., and CHATARD, THOMAS M. Chemicals and allied products. Group 4, Alums: Bureau of Census Bulletin 210, 1902, pp. 24-26.

Bauxite

EDWARDS, J. D., FRARY, F. C., and JEFFRIES, ZAY. The aluminum industry. New York, 1930, 358 pp.
FOX, CYRIL S. Bauxite. 2d ed. London, 1932, p. XXXI + 312 pp.
KNIBBS, N. V. S. The industrial uses of bauxite. London, 1928, pp. 108-115.

Processes

GARDNER, J. Acetic acid and vinegar, ammonia, and alum. London, 1885, pp. 147-193.
GESCHWIND, LUCIEN. The manufacture of alum and the sulphates and other salts of alumina and iron. London, 1901, pp. 182, 197, and 245-247.
URE'S DICTIONARY OF ARTS, MANUFACTURES, AND MINES. 7th ed. London, 1875, pp. 110 and 120-121.

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Domestic Deposits

HAYES, C. W. The Gila River alum deposits: U.S. Geol. Survey Bull. 315, 1907, pp. 215-223.
HEWETT, D. F. Deposits of magnesia alum near Fallon, Nevada: U.S. Geol. Survey Bull. 750, 1925, pp. 79-86.
SPURR, J. E. Alum deposits near Silver Peak, Esmeralda County, Nev.: U.S. Geol. Survey Bull. 225, 1904, pp. 501-502.

Uses

AUSTIN, WILLIAM E. Principles and practice of fur dressing and fur dyeing. New York, 1922, p. 56.
BAILEY, L. H. Development and use of baking powder and baking chemicals: U.S. Dept. of Agric. Cir. 138, 1931, 15 pp.
BAKER, M. N. Sketch of the history of water treatment: Journal, Amer. Water Works Assc., vol. 26, no. 7, July 1934, pp. 902-938.
COLLINS, W. D., LAMAR, W. L., and LOHR, E. W. The industrial utility of public water supplies in the United States: U.S. Geol. Survey Water-Supply Paper 658, 1934, pp. 21-30.
FEDERAL TRADE COMMISSION v. ROYAL BAKING POWDER COMPANY. Docket 540, 1920 to 1930.
HEDGEPATH, L. L. Coagulents used in water purification: Journal, Amer. Water Works Assc., vol. 26, no. 9, September 1934, pp. 1222-1223.
SCHULTZ, JACKSON S. The leather manufacture in the United States. New York, 1876, pp. 155 and 186.
TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY. Manufacture of pulp and paper, 1924, vol. 4, sec. 4, part 2, pp. 23-29, and vol. 5, sec. 2, part 2, pp. 33-46.

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